

INTRODUCTORY STUDY OF ADVANCED ORIBATE MITES (ACARIDA: CRYPTOSTIGMATA:
PLANOFISSURAE) AND A REDESCRIPTION OF THE ONLY VALID SPECIES OF
CONRICTOBATES (ORIPODOIDEA)

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The study of advanced oribate mites (Planofissurae, new name) is introduced as a further part of an ongoing study of sarcoptiform mites from South Australian surface soils. Morphology is considered with reference to a unified notation for hysteronotal chaetotaxy, notal pores, the form of leg trochanters, acetabula and apodemes. *Constrictobates lineolatus* Balogh and Mahunka is redescribed from South Australian material, the generic diagnosis is modified, Constrictobatinae (Lenicelidae) is newly synonymised with Pseudoppiinae (Oribatulidae), and the superfamily Oripodoidea is considered.

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This is a further part of an ongoing study of sarcoptiform mites from surface soil sampled from nine florally diverse South Australian sites. The primitive oribate mites have been considered elsewhere (Lee 1981, 1982, 1985), and here the study of advanced oribate mites is introduced. The majority of the oribate mites sampled belong to this group which, because of morphological changes, requires a consideration of homology and notation. Furthermore, because a new diagnostic character state for these mites is recognised, and the opinion that they should be unnamed (Lee 1985) is revoked, they are rediagnosed and dealt with under a new name (Planofissurae).

The description of the primitive oribate mites in this study has been thorough but time-consuming. Balogh & Mahunka (1983) suggest that 'painstaking scrutiny, using some recently discovered features' is not worth doing for only some members of a genus. Whilst appreciating this point, the paucity of a common denominator description is so limiting for many oribate mite groups that a more substantial level had to be undertaken, but not to such an extent as in my previous work. The dorsal and ventral aspects of the soma and the shape of the leg segments have been described, but not the gnathosternum or the chaetotaxy and form of the hairs on the legs.

The first superfamily to be considered is the Oripodoidea, partly because it is a diverse and dominant group within the well-established Poro-notae, and partly because it is not only important in the study of soil zoology, but some of its members are intermediate hosts of anoplocephalid tapeworms, being infected by the cysterceroid (bladder worm) stage. The most recent work on the

Oripodoidea is by Balogh & Balogh (1984), referring to it as the 'Oribatuloidea' as well as excluding the Mochlozetidae and Parakalummidae. It includes 20 families in the superfamily, of which half are listed as new. The work gives great importance to whether or not the hysteronotal foramina are multiporose, sacculate or a mixture of both those character states. The keys and diagnoses use few character states, which for Constrictobatinae (the only family group so far considered) are in part inaccurate. Despite this, the work is valuable on the basis for studying oripodoids.

Constrictobates was selected as an example, because it is unique within the Oribatuloidea in having 15 pairs of hysteronotal setae on the adult. This is only one pair less than in the holotrichous state amongst primitive oribate mites and is therefore valuable in homologizing the hysteronotal chaetotaxy of the two groups.

The South Australian mites examined are deposited in the South Australian Museum; the types have been returned to the Hungarian National Museum.

MORPHOLOGY

Hysteronotal chaetotaxy

There are three regularly used notational systems for the hysteronotal chaetotaxy, depending on whether they have a full complement of either 16, 15 or 10 pairs of setae. The multiplicity of systems is based on uncertainties of homology. I introduced another system (Lee 1981) for the primitive oribate mites (16-pairs chaetotaxy) with the intention of applying it to all sarcoptiform mites. The chaetotaxy

of oripodoid mites, for which both the 15-pairs and 10-pairs chaetotaxies have been used, is homologized here with the 16-pairs system as illustrated (Figs 1, 2). Because most advanced oribatid mites have 15 pairs of hysteronotal setae on the tritonymph, both systems have sometimes been used for one species. Certainly, with the substantial change in form between the nymphal and adult stages, any proposals of homology are uncertain. On the other hand, I consider that the heuristic advantage of a uniform notation outweighs the disadvantage of using an uncertain homology.

Previously (Grandjean 1954, Lee 1984) it has been stated that all Planolissuræ (=Circumdehiscenciae) lack seta *J4* (-/1). The loss of *J4* (and often *J2* and *J3*) occurs in the most primitive subsection of the Planolissuræ, the Pherenotac, with the exception of the Hermanniellidae where such setae are very small under the hysteronotal scalp, but there is a derived reversal of this loss and the seta that is absent from the 15-pair system of the oripodoid mites is *S2*.

The possible loss of setae in handling specimens, when only a few are available, can make it uncertain as to whether a setal base locates a vestigial or a broken off seta. In either case, it will be regarded as present in the chaetotaxy.

Notal pores

The slit-like pores (*h1*-*h6*) and the pore leading to the hysteronotal gland duct (*hG*) are treated as before, but the notation and signatures for the areolar pores, sacculi and reduced sacculi are changed. There is little doubt that these three structures

(sometimes referred to as octotaxic organs because four pairs are often conspicuous on the hysteronotum) are homologous, but their function is uncertain. They are often regarded as respiratory (Wallwork 1969), but they may be either respiratory or glandular (Hammen 1980). Here they are referred to as *foramina* (singular: *foramen*), and as either multiporose, sacculate, or uniporose. The term 'foramen' has been used for a thin patch bearing the infra-capitular gland orifice on the gnathosternum (Hammen 1983), but this is considered as the unnecessary commitment of a valuable term to a trivial structure. The commonest state of the foramina is multiporose, which is regarded as primitive. The hysteronotal foramina may be sacculate or uniporose, which are regarded as derived. Their signature is 'F' and the foramina are numbered depending on position: lateral proteronotal (*F1*), dorsosejugal (*F2d*), laterosejugal (*F2l*), the four hysteronotal pairs (*F3*, *F4*, *F5*, *F6*), a postanal strip (*F7*). A particular hysteronotal foramen may be divided into two parts, which are then given the signature suffix of either 'a' or 'b'.

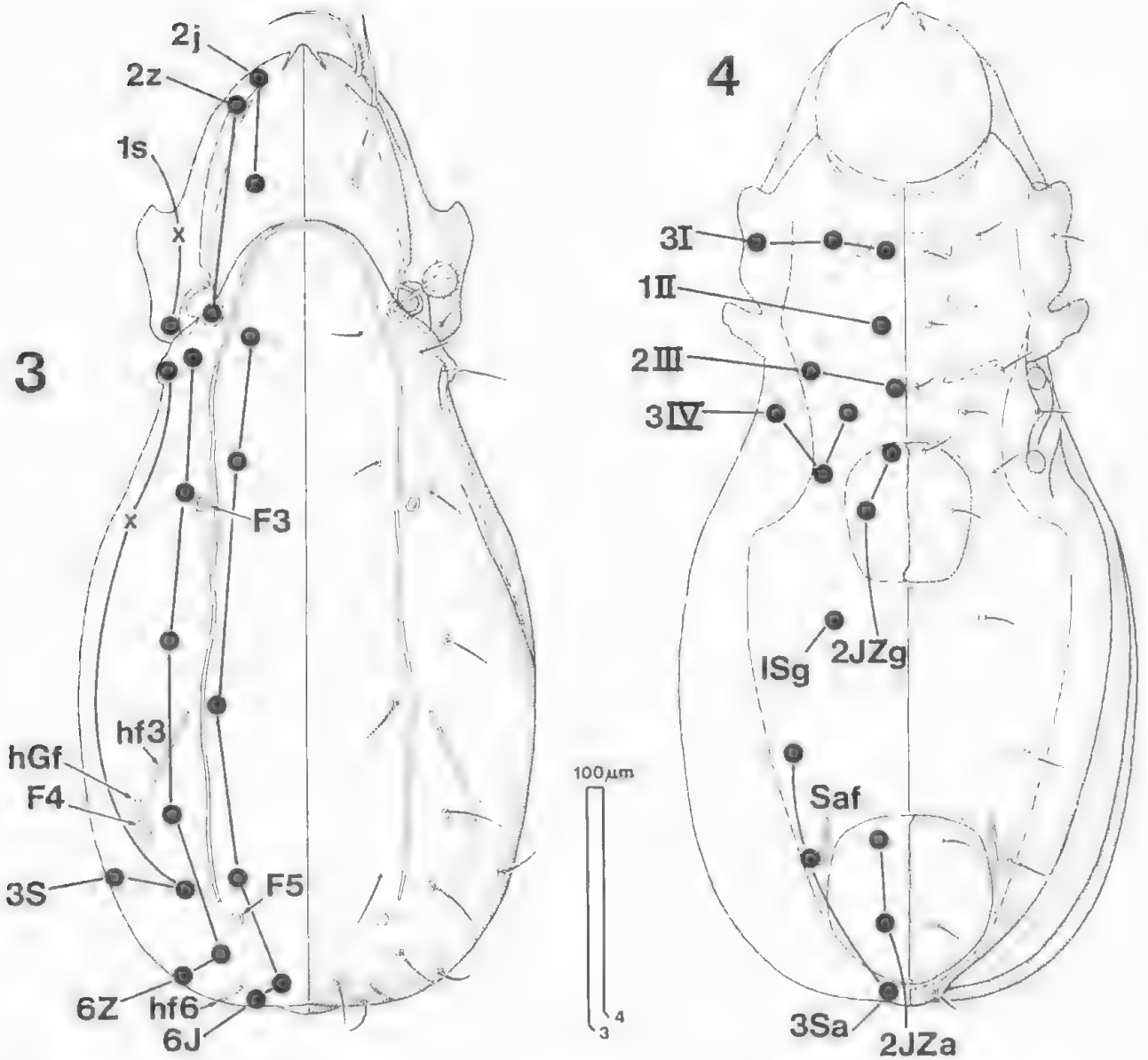
Form of leg segments (particularly the trochanter) and the acetabular cavity

Mite leg segments are primitively *subcylindrical*, with some tapering, and with only moderate variation in segment size. This is the case in primitive oribatid mite groups except that the coxa is merged into the podosoma. Diversification in shape and size has been derived in at least two suborders (Prolissurida, Comalida). It is difficult to rigidly categorize the various shapes, but the derived segment shape is termed *pedunculate*. The pedunculate segment has a caput, stalk and pedestal. The proximal stalk varies in relative size, as to whether it is gradually or abruptly delineated from the caput and as to whether its axis is continuous with or at an angle to that of the caput. The pedestal may be an inconspicuous flared out base to the stalk or it may be larger than the stalk and caput combined (Fig. 6 — note trochantera I and II, state found in all Planolissuræ).

The acetabulum is a socket in the coxite (merged coxa with podosoma). In most primitive oribatid mites the socket edge is level with the rest of the prosomatic exoskeleton, but there may be a derived state where the raised edge partly encloses the trochanter (e.g. *Phyllhermannia eisetosus* Lee, 1985: Fig. 5). In contrast, the trochanteral pedestal of the Planolissuræ is totally encompassed within an *acetabular cavity* (not illustrated since it is internal), which has a proximal *acetabulum* and an external aperture, termed the *acetabular access*. In the case of legs I and II, the trochanter is represented mainly by its pedestal, and is nearly absent externally. Apodemes extend from the proximal walls of

1			2				
S	Z	J	S	Z	J		
1	c3 ●	c2 ●	c1 ●	X	la ●	X	1
2	X	la ●	da ●	X	lc ●	X	2
3		lm ●	dm ●	X	li ●	X	3
4		lp ●	dp ●	rs ●		X	4
5	h3 ●	h2 ●	h1 ●	r3 ●	l2 ●	l1 ●	5
6	ps3 ●	ps2 ●	ps1 ●	n3 ●	p2 ●	p1 ●	6

FIGURES 1 AND 2. Equivalent notations for hysteronotal chaetotaxy used in this study (signatures at periphery with capital letters for files and numbers for ranks). 1, 15-pairs system (c2 etc.); 2, 10-pairs system (la etc.). X = seta absent, would be present in full complement of 16 setal pairs.



FIGURES 3 AND 4. *Constrictobates lineolatus*, female soma. 3, notum; 4, idiosternum.

acetabular cavities to bases on the prosternal integument. The full complement of *prosternal apodeme bases* is five pairs (I, II, sejugal, III, IV). There is also a pleural apodeme associated with the sejugal furrow, which merges dorsally with the bothridium to seta *z1*, termed the *bothridial apodeme*.

The trochanter is illustrated in this paper (Fig. 6) in order to demonstrate a synapomorphy of the Planofissurae, but when it is similar to this in later works it may not be figured. Although hairs of the legs are not normally considered, they may be illustrated in some cases in relation to segment shape as with the long, flagelliform solenidia on tubercles or a ventral setae near a flange a femur II.

Measurements

Measurements are in microns (μm) and applied as before (Lee 1981: 201), except that gnathosternal

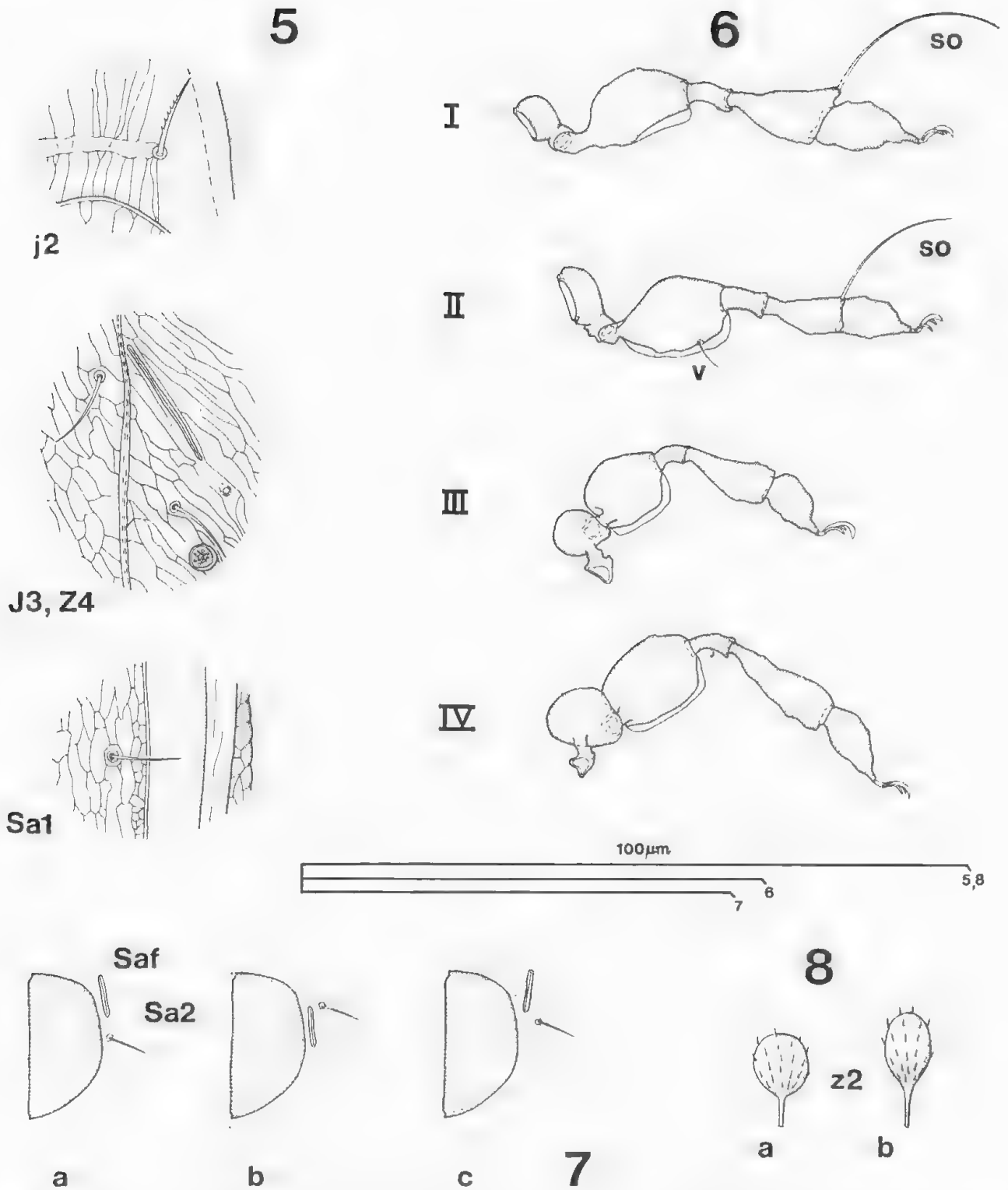
appendages are not considered. Also, because the trochantera are either obscured in the soma or have an angled stalk, they are excluded from the leg measurements. The length for a leg is the total of the lengths of each of the distal four segments (femur, genu, tibia, tarsus) disregarding the pretarsus, and the breadths are the greatest width (usually the height) of the tibia.

SYSTEMATICS

Section PLANOFISSURAE new name

Diagnosis (Adults)

Comalida. Holosomatina. Gnathosternum with dioxal fissure usually present. Leg trochantera pedunculate with pedestal (on legs I and II comprising most of segment) encompassed within acetabular cavity. Tracheae usually opening into



FIGURES 5-8. *Constrictobates lineolatus*, female. 5, integumental striations and structures around setae *j2*, *J3/Z4*, *Sa1*; 6, right legs I-IV, femora/tarsi — posterior aspect, trochantera — dorsal aspect; 7, various positions of pore and seta beside left anal shield; 8, proteronotal sensory seta (*z2*) with capitate (a) and clavate (b) forms.

some acetabular cavities. Leg genu usually less than quarter volume of tibia. Hysterosomal dehiscence line circumnotal.

Remarks

The Planofissurae is a well established taxon also known as the Circumdehiscenciae (Grandjean, 1954)

or the Euoribatida (Balogh & Mahunka, 1979). I have previously considered it as an unnamed taxon (Lee 1985: 50), preferring to use the slightly more extensive Holosomatina (= Brachypylina: Balogh 1972), regarding the fusion together of the coxites into a single shield in the latter taxon as a more important evolutionary event. Also, the Plano-

fissurae has been difficult to diagnose because the form of the hysteronotal dehiscence line is obscure (unless an exuvial 'scalp' is present), the genu is sometimes large and the dioxal fissure is sometimes secondarily lost or masked by a gnathosternal tectum. The recognition of the encompassing of the trochanteral pedestal as a diagnostic character state makes easy the identification of members of the Planofissuræ, and even if the somal integument is opaque, the external absence of any substantial part of trochanters I or II is ascertainable. Therefore, I now prefer to have this monophyletic taxon as a named group within the classification. There is a considerable disparity between its large size (over 100 families) and the size of the Clinofissuræ (Lee 1985: 50 — 6 families), the only other section within the Holosomatina. It has been given a new name to match that of its sister group and to emphasize its new lower rank. The Circumdehiscenciae is currently regarded elsewhere as one of seven cohorts within the Cryptostigmata (Johnston 1982), or as the Fuoribatida, being one of two suborders of Cryptostigmata (Balogh & Mahunka 1979).

The Planofissuræ generally includes two major groups; the Gymnonota (Pycnonoticae or Apterogastrina) and Poronota (Poronoticae or Pterogastrina). Previously I (Lee 1985: 49) reintroduced the use of Pherenotae for some members of the Gymnonotae. The Gymnonotae is further divided here so that the Planofissuræ includes the following five subsections with their characteristic superfamilies: Pherenotae (Gymnodamaeidea); Carinotae (Liacaridea); Gymnonotae (Oppioidea); Pliconotae (Tectocephoidea); Poronotae (Oripodoidea). This is intended to undermine a tendency in past classifications to represent the evolution of the Planofissuræ as a linear progression from the primitive Pherenotae to the advanced Poronotae. It is possible that three distinct lineages or subsections were derived from the Pherenotae, two of them monophyletic (Carinotae and Gymnonotae), whilst the Pliconotae may have given rise to the Poronotae. Such a model may prove inadequate, but it currently aids the search for alternatives to using the Gymnonotae as a large, probably polyphyletic taxon.

Superfamily ORIPODOIDEA Jacot

Oribatuloidea Thor: Woolley, 1958: 870 (part).
Oribatuloidea Thor: Balogh & Balogh, 1984: 257.
Excentrosclerosae Grandjean: Trávě, 1970: 209.

Nominotypical family-group; Oripodinae Jacot, 1925: 277.

Remarks

Dr R. A. Norton (State University of New York, Syracuse) has pointed out (pers. comm.) that Oripodidae is the senior valid name for any family grouped in the Oribatuloidea: Balogh & Balogh, 1984. The principal of co-ordination (Article 36, current Code of Zoological Nomenclature) requires that Oripodoidea is the senior available superfamily name and is valid for the taxon.

The Oripodoidea is one of the biggest superfamilies in the Cryptostigmata. No clear delineating diagnosis has been made for the adults. They usually have small fixed pteromorphs, but these structures may be either large and hinged or absent, and even the foramina (diagnostic of the Poronotae) may be absent. On the other hand, immatures may be diagnosed by being 'nymphes à microsclérites' (Grandjean 1954) later referred to the 'Excentrosclerosae' (Grandjean 1959). The replacing of 'Excentrosclerosae' by a superfamily name was considered by Grandjean (1959: 473), but he was concerned about the similarity of the included Mochlozetes to members of the Ceratozetoidea. Later, however, he considered (Grandjean 1960) that Mochlozetidae Grandjean 1960 were similar to Sellnickiidae Grandjean, 1960 and also, Trávě (1970) added Parakalummidae Grandjean, 1936 to the 'Excentrosclerosae'.

Subfamily PSEUDOPPIINAE Mahunka

Pseudoppiinae Mahunka, 1975: 293.
Constrictobatinae Balogh & Balogh, 1984: 280.

Type-genus: *Pseudoppia* Mahunka, 1975.

Diagnosis (Adults)

Planofissuræ. Poronotae. Oripodoidea. Oribatulidae. Proteronotal seta ζ 1 shorter than β 1. Lamellae usually absent (exception: *Constrictobates*). Hysteronotum pear-shaped, sejugal furrow extending anterior to bothridium (around seta ζ 2), may be evanescent or absent across mid-line. Hysteronotal setae in 11–15 pairs (always 6Z), setose (may have small cilia), not as long as distance between bases. Two pairs of hypertrophied slit-like pores ($h/3$, $h/6$) present. Either two, three or four pairs of small multiporose foramina present. Pteromorphs, if present, inconspicuous. Intercoxite apodemes transverse, short, not crossing midsternal line or reaching margin of genital aperture. Genital shield with two or three pairs of setae (exception: *Phauloppiella* with 4JZg).

Remarks

Balogh & Balogh (1984) ignored the part of the original diagnosis stating 'One pair of very small

area porosae' were present and regarded *Constrictobates* as 'Sacculonotic', whilst this paper records three pairs of multiporose foramina (= areae porosae). Therefore, *Constrictobates* should be grouped in the 'Poronotic' Oribatulidae rather than the Fencheliidae. The options were to either maintain the *Constrictobates* in the monotypical Constrictobatinae, to group it in the Pseudoppiinae or to disregard these subfamilies and place it in the large, diverse Oribatulinae. Relationships in the Oribatulidae are poorly understood and the maintenance of many small subfamilies is not advantageous, yet there is a group of genera including small species with few genital setae, an anterior extension of the hysteronotum into the proteronotal region and many hysteronotal setae. In order to recognise this group, Pseudoppiinae is considered valid and the Constrictobatinae its junior synonym. The delineation of this more extensive concept of Pseudoppiinae is open to argument. To follow the weighting by Balogh & Balogh (1984), the number of genital setae would be regarded as the most important diagnostic characteristic of the subfamily, but genera such as *Diphauloppia* Balogh & Balogh, 1984 and *Paraphauloppia* Hammer, 1967 with only two or three pairs of genital setae are excluded, whilst *Phauloppiella* with four pairs of such setae is included. This results from a weighting in preference of the number of hysteronotal setae because of differences in chaetotaxy (for example compare *Paraphauloppia*-3J, 5Z, 2S with *Senoribula*-2J, 6Z, 3S) as well as total number. The following five valid genera are included in the Pseudoppiinae: *Constrictobates* (see following); *Phauloppiella* Subías, 1977 (Spain-Pm); *Pseudoppia* Pérez-Inigo, 1966 (central Spain, east Pyrenees-Pm); *Symphauloppia* Balogh, 1972 (Bulgaria-Pm); *Senoribula* Mahunka, 1975 (Senegal-Ee near Pm). The three genera (*Pseudoppia*, *Senoribula*, *Symphauloppia*) originally making up the Pseudoppiinae are more similar to each other than to the distinctive *Constrictobates* and *Phauloppiella*.

Genus *Constrictobates* Balogh & Mahunka

Constrictobates Balogh & Mahunka, 1966: 559.

Type-species: *Constrictobates lineolatus* Balogh & Mahunka.

Diagnosis (Adults)

Pseudoppiinae. Hysteronotum with 15 pairs of setae (S2 absent), 3 pairs of multiporose foramina (F3, F4, F5). Sejugal furrow continuous across mid-dorsal line. Lamellae present but flattened (seta z1-z2). Minute, horizontal pteromorph bearing setae Z1 and S1. Three prosternal apodeme bases (I, II,

sejugal) present. Anterior margin of genital aperture and acetabulum IV transversely level. Two pairs of setae on both genital (2/Zg) and anal (2/Za) shields. Legs short (order of decreasing length: I, IV, II, III) tarsi only about twice genu length, three pretarsal claws.

Remarks

Constrictobates includes one species previously recorded only from Western Australia. It was established in the Oribatulidae and, after being grouped in the Fencheliidae by Balogh & Balogh (1984), is now returned to the Oribatulidae (see Remarks on Pseudoppiinae). The material from South Australia is described here and compared with type material to correct original description inaccuracies and indicate intraspecific variations. The South Australian specimens are smaller and usually have a few character states differing from the type series, but not in all cases.

Constrictobates lineolatus Balogh & Mahunka (Figs 3-8)

Constrictobates lineolatus Balogh & Mahunka, 1966: 561.

Female

General appearance and measurements: Minute to small, dull yellow brown, cerotegument inconspicuous (sometimes evident as a granular, translucent layer partly detached around leg bases or posterior somal margin). Somal setae, other than proteronotal file 1 and 2, medium length but fine and inconspicuous. Somal integument covered in fine furrows forming a reticulate pattern (Fig. 5), but superficially appearing as longitudinal striae, with only limited smooth patches (rostrum, lamella region and a pleural strip on ventral shield lateral to seta Sa1). Idiosomal length 207 (25 ex Tamboore, 183-217); 213 (1 ex Ferris-McDonald Reserve); 228 (holotype and three paratypes). Appendage lengths (for 215, ex Tamboore)-I 88, II 72, III 68, IV 79; tibial heights-I 15, II 9, III 10, IV 10.

Prosternum: Mentotectum width variable, narrow (Fig. 4) to broad (~ setal base distance 11-11). First apodeme base conspicuous, beside apodeme bases some faint external ridges between coxite zones. Coxisternal setae with seven pairs on flat mid-venter (J2 large) and two pairs on lateral tecta (J3-pedotectum 1, IV3-discidium).

Proteronotum: Rostral margin tripartite. Lamella flattened (regardable as costula) extends anterior to seta z1 and posteriorly notched between it and circumbothridial ridge, which has hyaline flap ventral to seta z2. Three stout setae (j1, j2, z1) all ciliate, conspicuous proximally on abaxial surface of j1, inconspicuous on j2 and z1. Seta j2 finer than

z1, but sometimes similar in length (not as Fig. 3). Fine furrows restricted to near seta j2 and shallow groove between setae j2-j2 (Fig. 5). Seta j1 at anterior end of short ridge. Seta s2 inconspicuous, fine about a third length of j2, ventral to z2. The sensory seta z2 varies from clavate to capitate (Fig. 8), with elia in longitudinal files, and often fewer on globose head of capitate state, also transverse profile may be either circular or oval.

Opisthosternum: Genital shield only slightly anteriorly transposed into region between leg acetabula. Substantially unpatterned lateral strip on ventral shield (Fig. 5) abaxial to seta Sa1. Considerable variation in relative positions of seta Sa2 and pore Saf (Figs 4, 7), with commonest state on South Australian material being Saf parallel to and hardly extending anterior to anal aperture, whilst base of seta Sa2 about level with posterior end of pore (Fig. 4). Posterior setal pair (Sa3) on protrusion of ventral shield.

Hysteronotum: Reticulate pattern of fine furrows (Fig. 5) divided into mid-dorsal and two lateral zones by a more substantial furrow (Fig. 3), which merges anteriorly with the sejugal furrow. Some variation in length of 15 pairs of hysteronotal setae, seta S1 longest and stoutest, sometimes more than twice length of Z1. Pteromorph minute, sometimes blunt (Fig. 3), sometimes pointed, base of seta S1 central or biased. Three pairs of multiporose foramina small (F4 largest), raised rim, ventral 'blister' with 7-13 pores clustered in middle (Fig. 5), foramina F5 unusual amongst oribatuloids in positioning anterior not posterior to seta Z5. Anterior hypertrophied slit-like pore (hf3) conspicuous, posterior pore (hf6) as long, only small part visible from above (Fig. 3).

Legs: Legs short, longest (I, femur-tarsus) 41% idiosomal length. Tarsi particularly short (all less than tibia, Fig. 6), thick (breadth more than 50% length). Tarsus III with distinctive bulbous base. All femora anteroposteriorly flattened with shallow ventral flange, not bearing ventral setae (e.g. femur II, seta v, Fig. 6). Long flagellium solenidium on tibia I and II. Pretarsal central claw longer and more robust than lateral claws.

Somal inclusions: Ovipositor involuted tube length, 65 (soma 215), three lobes length 20. Bears 18 setae, subequal in size to each other, longer and more robust than proteronotal seta j2, proximal setae (pg) unusually distal in position with lips reaching bases of distal setae (dg). No eggs observed. One to three holes in each female, sometimes translucent and granular (? bacteria), occasionally unrecognisable fragments or spherical spores, rarely multicellular fragments.

Mite

Measurements and spermapositor (otherwise as female): Idiosomal length 193 (25 ex. Tamboore.

177-204), 216 (holotype). Spermapositor breadth (anterior-posterior, length shorter) -16, sclerotized bilobed shield length -13, bearing 12 very small (shorter than proteronotal seta s2) subequal setae.

Material examined

Twenty-five females (N1986193-N1986217) and twenty-five males (N1986218-N1986242), leaf litter under banksia shrubs (*Banksia ornata*), Tamboore (35°57'S, 140°29'E), 4.7.1974, D. C. Lee. Holotype male and three paratype females (Hungarian Natural History Museum), leaf litter under dry sclerophyll woodland (*Eucalyptus marginata* and *E. calophylla*), Mt Toolbrunup (34°23'S, 118°03'E), Stirling Ranges, 7.6.1953, G. E. Bornemissza.

Distribution

Australia (Au). Western Australia; Stirling Ranges, dry sclerophyll open-woodland, 13 adults (types). South Australia; Ferries-McDonald Reserve, mallee-heath tall open-shrubland, 1 female/1 of 8 × 25 cm²; Tamboore, mallee-heath tall open-scrubland, 39 females, 37 males /4 of 8 × 25 cm² (69 adults in one 25 cm² sample).

Remarks

Initially, the South Australian material was thought to be a new species. It has been established that this was because of inaccuracies in the original description of the only valid species and because of morphological intraspecific variation. The South Australian specimens are smaller than the type material but are similar enough to be grouped in *C. lineolatus*.

Important differences between the specimens and the original description are as follows: proteronotum with short rostrum (seta j1 close to, rather than well separated from z1); sejugal furrow complete; 15 pairs of hysteronotal setae (J5 and Z5 overlooked); three pairs of multiporose foramina (two pairs overlooked); two pairs of hypertrophied slit-like pores (hf6 overlooked); hysteronotal seta S1 twice as long and stout as Z1 (described as subequal).

Intraspecific variations amongst South Australian specimens (sometimes between right and left sides) as follows: pore (Saf) and seta (Sa2) beside anal shield mostly as first illustrated (Fig. 4), varies to three other positions (Fig. 7) of which one is as types (Fig. 7c); sensory proteronotal seta z2 usually capitate (Fig. 8a), sometimes clavate as on types (Fig. 8b); size of a number of setae varies (j2, s2, S1), usually smaller than on types.

ACKNOWLEDGMENTS

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